# T-NASA Taxi Test at Atlanta Airport

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The Terminal Area Productivity Program/Low-Visibility Landing and Surface Operations element is developing cockpit technologies to enable safe and efficient surface operations in Category IIIB (300–700-feet runway visual range) visibility conditions. Ames Research Center is developing an integrated display system, the T-NASA (Taxiway Navigation and Situation Awareness) system, consisting of conformal symbology on a head-up display (HUD; see first figure), an electronic moving map (EMM; second figure), and three-dimensional (3-D) audio alerts for impending traffic incursions. The T-NASA Taxi HUD uses scene-linked symbology projected on glass overlaying the forward scene to present taxi route information, situational awareness information, and ground speed. The EMM depicts the cleared taxi route on the airport surface, as well as real-time information about own-ship position, other airport traffic, and hold-short locations. The 3-D Audio Ground Collision Avoidance System (GCAS) presents spatially localized auditory traffic and navigation warnings.

A joint flight test was conducted at Atlanta's Hartsfield International Airport to evaluate Ames Research Center's HUD and EMM components of the T-NASA system. Langley Research Center conducted the integration of T-NASA into NASA's 757 aircraft, and the Federal Aviation Administration developed the airport surveillance and data-link technologies.


*Fig. 1. Scene-linked T-NASA Taxi HUD symbology (green) showing high-speed exit off of runway and cleared taxi route overlaid on night airport scene. Text symbology shows ground speed and current position.*

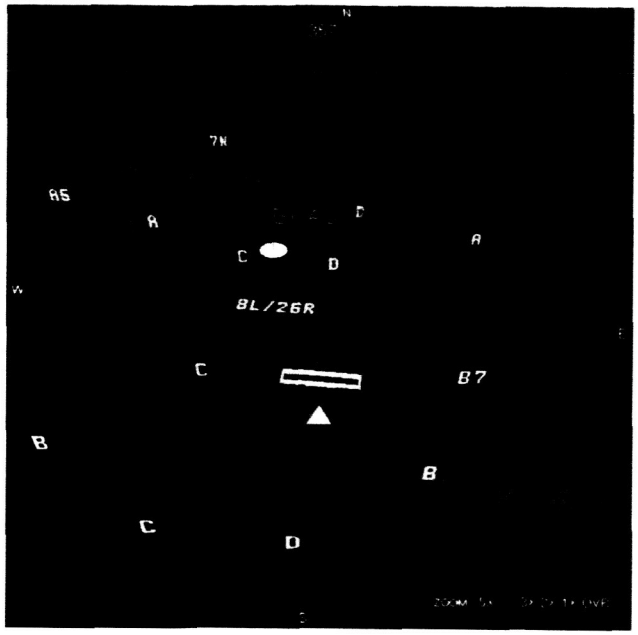


*Fig. 2. Electronic moving map display of Atlanta's Hartsfield International Airport from field test. Features shown are the current location of the test aircraft (white triangle); the cleared taxi route (magenta line); the position of another taxiing airplane with flight tag information (white circle); and hold bar indicating air traffic control hold short of the active runway (yellow and red bar).*

Fifty-three flights were conducted by two NASA test pilots and four commercial pilots from different airlines. Taxi operations were conducted under night visual flight rules (VFR) conditions to emulate low-visibility conditions. Pilots completed taxi trials with three different T-NASA configurations: (1) Baseline—Jeppesen paper chart only; (2) EMM only; and (3) EMM plus HUD. Aircraft state data, such as velocity and heading, were electronically recorded. Formal questionnaire assessments were made by the pilots after each trial, and a questionnaire and debriefing interview was administered after each day of testing.

Pilot reports indicated that T-NASA reduced overall taxi times by allowing for increased taxi speeds; by requiring less route planning time, less time at confusing intersections, and fewer stops while taxiing; by improving situation awareness; and by providing greater confidence in the aircraft's position on the airport surface. These subjective reports were supported by objective velocity data collected during the flight test. Further, during one of seven baseline taxi trials in which the T-NASA system was turned off, the pilot turned onto the wrong taxiway—this never happened when the T-NASA system was activated. This was a good example of lowered situational awareness and time wasted at confusing intersections without the T-NASA system.

All four commercial pilots agreed that T-NASA technology would improve taxi safety, primarily by reducing the likelihood of incursions. As another indication of safety, pilots stated that the Jeppesen chart "distracted" them from taxiing and that neither the EMM nor the EMM-plus-HUD configurations were distracting. T-NASA system allowed the pilots to spend more time looking out the window and less time head-down consulting the Jeppesen chart. Also, all pilots unanimously agreed that both the EMM and the EMM-plus-HUD configurations increased situational awareness and reduced mental navigational workload during taxi operations. Furthermore, pilots noted that T-NASA system improved communications with ground control and between crew members, because there was less need for communication and communications were clearer. One pilot's company trip report succinctly summarizes the flight tests: "This research by NASA represents a quantum step in air operations safety and technology, on the same level as the development of the Ground Proximity Warning System and the Traffic Collision Avoidance System," and "this system is very usable and demonstrated its design goal of improving the speed and accuracy of ground operations, reducing task loading, and enhancing overall situation awareness and safety in a complex, high-density traffic environment."

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